


Chapter 8

Digital Exposome: A Digital Age Approach to Environmental Exposure and Cancer Risk Assessment

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ABSTRACT

The digital exposome integrates digital technologies, multi-omics analysis, and artificial intelligence to holistically assess environmental exposures across human life, particularly their contribution to cancer risk. Chemical, physical, biological, social, and behavioral factors are critically examined, emphasizing prenatal vulnerability. Wearable sensors, geographic information systems (GIS), and spatial mapping technologies enable real-time biomonitoring and precise visualization of exposures. Multi-omics and epigenetic modeling further clarify biological mecha-

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nisms linking exposure to cancer, while machine learning supports big data-driven risk classification and identification of vulnerable populations. This approach enhances early detection and targeted prevention strategies and supports inclusive, evidence-based public health policies.

INTRODUCTION

Cancer is the second leading cause of death worldwide, accounting for more than 19.3 million new cases and 10 million deaths in 2020 (IARC, 2020). The World Health Organization projects that the number of new cancer cases will rise to 28.4 million by 2040, primarily driven by factors such as population aging, urbanization, and changes in lifestyle patterns (Lewandowska et al., 2019). Recent studies have highlighted that the majority of cancer risks are linked to modifiable factors, including environmental exposures, smoking habits, and social inequalities (Bryere et al., 2019; IARC, 2020). It is estimated that more than half of cancer cases could be prevented through effective risk management strategies. Notably, environmental carcinogens such as delicate particulate matter (PM_{2.5}), volatile organic compounds (VOCs) like benzene and formaldehyde, and endocrine-disrupting chemicals (EDCs) such as phthalates and bisphenol A (BPA) have been associated with an elevated risk of cancer development (Ahn & Jeung, 2023; Tseng et al., 2019).

Social determinants—such as poverty, pollution, and limited access to healthcare—exacerbate this burden, particularly in developing nations (Bhattacharjee et al., 2022). To address this complexity, the exposome framework—introduced by Wild in 2005—captures lifelong environmental exposures and their biological effects. It highlights mechanisms like inflammation, oxidative stress, and epigenetic changes linked to carcinogenesis (Go et al., 2023). With digital innovation, the digital exposome enhances this framework by integrating wearable sensors, GIS, multi-omics, and machine learning for real-time exposure mapping and personalized analysis (Vermeulen et al., 2020). These tools help identify exposure hotspots and decode molecular responses. The digital exposome significantly advances cancer research by enabling real-time mapping of external exposures—such as pollutants, diet, and social environment—and internal biological responses like metabolism and stress regulation. It facilitates precise exposure tracking through sensors, mobile devices, GPS, air quality monitors, and citizen science data. It facilitates cancer patients to further connect exposure events with biological changes, enhancing early detection, risk stratification, and understanding of metastasis mechanisms.

Particularly critical is the prenatal period, where exposures to pollutants such as PAHs and EDCs may cause long-term epigenetic changes and cancer risk (Sun et al., 2019). In vitro models and organoids now facilitate studying exposure-induced

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